Loads and Dynamics ARAC WG Report for 25.415 Ground Gust
18 June 2001
Harmonization (Category 3) and New Projects

1 - What is underlying safety issue to be addressed by the FAR/JAR?

CFR 14 Amendment 25-91 increased the ground gust velocity requirement for § 25.415 from 60 MPH (52 Knots) TAS to 65 KTAS. However based on several incidents that have occurred to aircraft on the United Kingdom register and at least one aircraft on the US register, it has been determined that the effects of control system flexibility can lead to internal loads greater than those corresponding to the hinge moments prescribed by § 25.415. Although damage from ground gusts may not be an immediate hazard, the rule is intended to prevent damage to the control system that may not be detected before take-off. The JAA Structures Study Group has developed a draft NPA 25C-284 in response to this issue.

The L&D HWG was assigned the task of harmonizing FAR and JAR 25.415 as a Fast Track Category 1 item. However the existence of the draft NPA 25C-284 and the safety issues addressed therein caused the L&D HWG to successfully petition for a change in the Fast rack Category to Category 3. Currently the rules § 25.391 through § 25.415 are convoluted and confusing and have lead to differing interpretations being utilized as the basis for compliance.

2 - What are the current FAR and JAR standards relative to this subject?

Current FAR text:

(a) The control system must be designed as follows for control surface loads due to ground gusts and for taxiing downwind:
  (1) The control system between the stops nearest the surfaces and the cockpit controls must be designed for loads corresponding to the limit hinge moment of paragraph (a)(2) of this section. These loads need not exceed -
  (i) The loads corresponding to the maximum pilot forces in 25.397(c) for any pilot alone or
  (ii) O.75 times these maximum loads for each pilot when the pilot forces are applied in the same direction
  (2) The control system stops nearest the surfaces , the control system locks and the parts of the system (if any) between these stops and locks and the control surface horns, must be designed for the limit hinge moments H, in foot pounds, obtained from the formula,

$H = .0034KV^2cS$, where__
V = 65 (wind speed in knots)

K = limit hinge moment factor for ground gusts derived in paragraph (b) of this section.
c = mean chord of the control surface aft of the hinge line (ft);
S = area of the control surface aft of the hinge line (sq ft);

(b) The limit hinge moment factor K for ground gusts must be derived as follows:

	Surface	*K*	Position of controls
	(a) Aileron ----------	0.75	Control column locked or lashed in mid-position.
	(b) Aileron ---------- (c) Elevator---------- (d) Elevator---------- (e) Rudder---------- (f) Rudder----------	*±0.50 *±0.75 *±0.75 0.75 0.75	Ailerons at full throw. (c) Elevator full down. (d) Elevator full up. (e) Rudder in neutral. (f) Rudder at full throw.

* A positive value of *K* indicates a moment tending to depress the surface, while a negative value of *K* indicates a moment tending to raise the surface.

Current JAR text (As of Change 15):

Same as above FAR text.

2a – If no FAR or JAR standard exists, what means have been used to ensure this safety issue is addressed?

Not applicable.

3 - What are the differences in the FAA and JAA standards or policy and what do these differences result in?

There are no differences in current standards. It is however a JAA policy that for aircraft where the dynamic response of control systems may be significant for ground gusts, the dynamic effects of control systems be taken into account. The JAA requires consideration of the control systems "locked" while moored and "unlocked" when taxing downwind.

4 - What, if any, are the differences in the current means of compliance?

Discussed in item 3.

5 – What is the proposed action?

Develop an NPRM with the following requirements:

§ 25.391 Control surface loads: general.

The control surfaces must be designed for the limit loads resulting from the flight conditions in §§ 25.331, 25.341(a) and (b), 25.349 and 25.351 ~~and the ground gust conditions in Sec. 25.415~~, considering the requirements for -

(a) Loads parallel to hinge line, in § 25.393;
(b) Pilot effort effects, in § 25.397;
(c) Trim tab effects, in § 25.407;
(d) Unsymmetrical loads, in § 25.427; and
(e) Auxiliary aerodynamic surfaces, in § 25.445.

§ 25.395 Control Systems

(a) (retain current text)
(b) The system limit loads <u>of paragraph (a)</u>~~, except the loads resulting from ground gusts,~~ need not exceed the loads that can be produced by the pilot (or pilots) and by automatic or power devices operating the controls.
(c) (retain current text)

§ 25.415 Ground gust conditions.

(a) The flight control systems and surfaces must be designed for the limit loads generated when the aircraft is subjected to a horizontal 65 knots ground gust from any direction, while taxiing with the controls locked and unlocked and while parked with the controls locked.

(b) The control system and surface loads due to ground gust may be assumed to be static loads and the hinge moments H, in foot pounds, must be computed from the formula,

$H=K\ 1/2\rho_o V_{fps}^2 cS$

where:
K = hinge moment factor for ground gusts derived in paragraph (c) of this paragraph
ρ_o = density of air at sea level = .0023769 (slugs/ft^3) = .0023769 (lb-sec^2/ ft$^{4)}$
V = 65 knots = 109.71 fps relative to the aircraft
S = area of the control surface aft of the hinge line (ft^2)
c = mean aerodynamic chord of the control surface aft of the hinge line (ft)

(c) The hinge moment factor K for ground gusts must be taken from the following table:

	Surface	*K*	Position of controls
	(a) Aileron ----------	0.75	Control column locked or lashed in mid-position.
	(b) Aileron ---------- (c) Elevator---------- (d) Elevator---------- (e) Rudder---------- (f) Rudder----------	*±0.50 *±0.75 *±0.75 0.75 0.75	Ailerons at full throw. (c) Elevator full down. (d) Elevator full up. (e) Rudder in neutral. (f) Rudder at full throw.

* A positive value of *K* indicates a moment tending to depress the surface, while a negative value of *K* indicates a moment tending to raise the surface.

(d) The computed hinge moment of paragraph (b) must be used to determine the limit loads due to ground gust conditions for the control surface. A 1.25 factor on the computed hinge moments must be used in calculating limit control system loads.

(e) Where control system flexibility is such that the rate of load application in the ground gust conditions might produce transient stresses appreciably higher than those corresponding to static loads, in the absence of a rational analysis an additional factor of 1.6 must be applied to the control system loads of paragraph (d) to obtain limit loads. If a rational analysis is used, the additional factor must not be less than 1.20.

(f) For the condition of the control locks engaged, the control surfaces, the control system locks and the parts of the control systems (if any) between the surfaces and the locks must be designed to the respective resultant limit loads. Where control locks are not provided then the control surfaces, the control system stops nearest the surfaces and the parts of the control systems (if any) between the surfaces and the stops must be designed to the resultant limit loads. If the control system design is such as to allow any part of the control system to impact with the stops due to flexibility, then the resultant impact loads must be taken into account in deriving the limit loads due to ground gust.

(g) For the condition of taxiing with the control locks disengaged, the following apply:

(1) The control surfaces, the control system stops nearest the surfaces and the parts of the control systems (if any) between the surfaces and the stops must be designed to the resultant limit loads.

(2) The parts of the control systems between the stops nearest the surfaces and the cockpit controls must be designed to the resultant limit loads, except that the parts of the control system where loads are eventually reacted by the pilot need not exceed:

(i) The loads corresponding to the maximum pilot loads in § 25.397 (c) for each pilot alone; or

(ii) 0.75 times these maximum loads for each pilot when the pilot forces are applied in the same direction.

For each proposed change from the existing standard, answer the following questions:

6 - What should the harmonized standard be?

See question 5.

7 - How does this proposed standard address the underlying safety issue (identified under #1)?

An improved standard has been developed that removes ambiguities in the current regulations and also accounts for dynamic affects by requiring the simple use of factors that are applied to the loads. An additional factor is required for systems where dynamic effects may be significant. The approach is simple and will lead to consistent design requirements.

8 - Relative to the current FAR, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.

Current level of safety is increased due to the elimination of confusing requirements and by requiring higher control system and control surface design loads requirements for ground gust where it is appropriate.

9 - Relative to current industry practice, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.

Increases the level of safety. Many manufacturers have designed their control systems to account for the dynamic effects for ground gust. However such analyses are very complex and lead to a wide range of possible results. The proposed changes are based upon factors that are applied to static analyses that will result in more reliable and uniform certification compliance. Dynamic analysis is still allowed as an option. However, when dynamic analysis is used minimum increases in loads due to dynamic effects are specified as a floor design level.

10 - What other options have been considered and why were they not selected?

The JAA has required that the dynamic effects be accounted for by analysis. Due to the difficulties in doing such analysis, the HWG believes that the proposed standard is more appropriate.
The L&DHWG reviewed the issue of potential control system damage during aircraft ground operations in ground gust conditions. An issue had been raised regarding the potential for control system damage due to impact of the surfaces with the stop with the gust locks disengaged and with the control system not constrained by the pilot.

The concern is for reversible systems such as manual systems that do not have a significant amount of damping.

The following conclusions have been reached:

1. The design load level has been increased by a factor of at least 2.5 relative to earlier design requirements for systems with significant flexibility.

2. The proposed rule addresses the effect of control surface impact with the control stops for flexible systems.

3. The L&DHWG does not feel that it is reasonable to operate an aircraft with manual control systems in design ground gust conditions with the pilot not constraining the control systems. This is supported by the FAA Flying Handbook FAA-H-8083-3 Chapter 2 for Ground Operations.

4. Some aircraft have operational procedures that require the gust lock to remain engaged until shortly before takeoff.

5. The L&D HWG is not aware of conclusive evidence of failure of the control systems when the pilot is not constraining the flight controls.

6. Therefore the L&DHWG believes that the requirements that have been developed for the instance where the pilot constrains the flight controls are adequate.

7. The L&DHWG recommends that the TAEIG consider the need for additional operational procedures or the development of pilot informative material regarding the need for constraint of the flight controls during ground operations.

11 - Who would be affected by the proposed change?

Airplane manufacturers.

12 - To ensure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble?

A new ACJ is recommended based upon the draft AC per below.

13 - Is existing FAA advisory material adequate? If not, what advisory material should be adopted?

There is no existing FAA advisory material. A draft AC 25.415-1 , as attached, is proposed along with a corresponding ACJ.

14 - How does the proposed standard compare to the current ICAO standard?

The current ICAO standard has no specific criteria for ground gust analysis.

15 - Does the proposed standard affect other HWG's?

No.

16 - What is the cost impact of complying with the proposed standard?

Economic analysis still to be done but it is expected to be small in comparison to standard industry practice.

17. - If advisory or interpretive material is to be submitted, document the advisory or interpretive guidelines. If disagreement exists, document the disagreement.

Draft Advisory Circular AC 25.415-1 is submitted.

18. - Does the HWG wish to answer any supplementary questions specific to this project?

Not at this time.

19. – Does the HWG want to review the draft NPRM at "Phase 4" prior to publication in the Federal Register?

Yes

20. – In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rulemaking project, or is the project too complex or controversial for the Fast Track Process? Explain.

It is appropriate for the "Fast Track" process.